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# **EXPERIENTIAL KNOWLEDGE REPRESENTATION AND THE DESIGN OF PRODUCT USABILITY**

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## **Abstract**

The topic of designers' knowledge and how they conduct design process has been widely investigated in design research. Understanding theoretical and experiential knowledge in design has involved recognition of the importance of designers' experience of experiencing, seeing, and absorbing ideas from the world as points of reference (or precedents) that are consulted whenever a design problem arises (Lawson, 2004). Hence, various types of design knowledge have been categorized (Lawson, 2004), and the nature of design knowledge continues to be studied (Cross, 2006); nevertheless, the study of the experiential aspects embedded in design knowledge is a topic not fully addressed. In particular there has been little emphasis on the investigation of the ways in which designers' individual experience influences different types of design tasks.

This research focuses on the investigation of the ways in which designers inform a usability design process. It aims to understand how designers design product usability, what informs their process, and the role their individual experience (and episodic knowledge) plays within the design process. This paper introduces initial outcomes from an empirical study involving observation of a design task that emphasized usability issues. It discusses the experiential knowledge observed in the visual representations (sketches) produced by designers as part of the design tasks.

Through the use of visuals as means to represent experiential knowledge, this paper presents initial research outcomes to demonstrate how designers' individual experience is integrated into design tasks and communicated within the design process. Initial outcomes demonstrate the influence of designers' experience in the design of product usability. It is expected that outcomes will help identify the causal relationships between experience, context of use, and product usability, which will contribute to enhance our understanding about the design of user-product interactions.

## **Keywords:**

Experiential knowledge; Tacit knowledge; Usability; Product design; Knowledge representation

## **Introduction**

Experience underlies all kind of human knowledge and it is context dependant; people's experience within a particular social, cultural and physical context-of-use determines how they interact with products. This concurs with various research that investigated experience and its relevance for the design of products from various perspectives (Forlizzi and Ford, 2000; Jordan, 2002; Rosch, 2002; Kuniavski, 2003; Sleswijk Visser, Stappers, Van der Lugt and Sanders, 2005; Battarbee and Koskinen, 2005; Popovic and Kraal, 2008). In design, experience related research has been mostly centred on enhancing the development of more pleasurable user-product interactions (Sanders, 2002; Overbeek, Djadjadiningrat, Hummels and Stephan, 2002; Sengers, 2003).

This paper presents a work in progress; a continuation of Chamorro-Koc (2008) preceding study that focused on identifying the relationships between human experience and products' context-of-use and the ways in which these inform the design of products. This study aims to build on these findings and extend the previously identified design principles. It is expected that understanding how experiential

knowledge influence on the way people relate to products and the way designers inform their design process, will contribute to enhance the design of user-product interaction.

The following sections introduce the background study and describe the sources of experience identified as significant to the design of product usability. The current investigation, the research design, its aims and methodology are explained next. They are supported by examples of the instruments and stages of the experiment. Next, analysis of the initial outcomes is presented along with segments of the data collected in order to demonstrate arising issues and describe the emerging coding system. An initial interpretation of results is then described, and initial outcomes including types of experiential knowledge are discussed. Finally, the conclusions section outlines future research directions.

## **Experiential knowledge and causal relationships**

Lawson (2004) explains that both theoretical (precedents) and experiential knowledge inform the design process, but they are stored and recalled in different ways. They are two independent systems. Precedents are partial pieces of information (designs) that the designer is aware of, and have not been experienced live, but through images in internet, books, magazines, and television. Differently, experiential knowledge comes from events in the designers' life, and they can be remembered with great level of detail.

The designers' knowledge has been studied as part of research into design thinking; however, an issue not addressed in earlier investigations is about the ways in which users' experiential knowledge informs their interactions with products, and how to bring such information into the design process. Chamorro-Koc (2008) empirical study identified relationships describing the aspects of human experience influencing users' understanding of everyday products. It established similarities and differences between designers' and users' concepts of a product use arising from experiential knowledge, and verified the applicability and relevance of these findings for the early stage of a design process. The research approach employed visual representation of concepts, retrospective verbal reports and interviews to elicit users and designers' concepts about their experience and concepts of a product's use and of its context of use. Visual representation of concepts was employed to elicit the participants' concepts of a product, and to reveal aspects of their experience with regard to their user-product interactions. The use of visuals to reveal aspects of experience is supported by previous studies in which images produced during research have been studied as representations of reality — who, where, and what — (Van Leeuwen and Jewitt, 2001), and by studies in which visuals have been studied as representations of experience or knowledge (Oxman, 2002; Rosch, 2002; Tang, 2002; Dahl, 2001). It is important to note that in the design domain, words, images and shapes in combination or independently, are used to communicate the concepts and represent the understanding of the physical world of artifacts. These are the most common media that designers use to interpret and reformulate the design concepts. They also convey representation of experiential knowledge (Popovic, 2004). In the earlier Chamorro-Koc's (2008) study, retrospective verbal reports were employed to allow participants describe and explain their visual representation of concepts, to point out any aspect that they could not convey in the drawings, and to support clearer understanding of tacit knowledge used during the design process. This approach follows previous studies that found experience as a subjective event comprehended only by the person who experiences it (Sanders, 2001), and that the interpretation of any kind of representation from a person's own experience must be done by the person himself or herself (Loizos, 2000). Interviews were employed to gain further insights into what the participant 'say and think' (Sanders, 2002) about the concepts revealed in visuals and retrospective reports, and to provide an opportunity to participants to expand their previous responses. The experiment sessions were video- and audio taped (Chamorro-Koc et al., 2008).

Data collected in sketches, videos, and interviews, show that users' knowledge of product use - tacit knowledge - comprises knowledge emerging from the experience of using a product or from seeing a product in its context of use. This agrees with other studies about experiential knowledge suggesting that tacit knowledge is primarily seen from an individual's actions (Polanyi, 1996). Chamorro-Koc's (2008) findings identify four sources of human experience influencing people's understanding of product usability; these are: familiarity, episodic experience, experience from cultural background, and experience from expert domain. It is understood that cultural background generates strong concepts of a product's social context-of-use which is ingrained in a particular culture or tradition. Thus, the user's cultural background influences his or her understanding of a product's usage and its context-of-use. It can also generate knowledge about the product's intended use, a description of its features in the context-of-use, and principle-based concepts that explain the product's functionalities. These relationships can be employed in the early stages of the design process to inform designers about the areas of human experience that must be addressed to support particular aspects of the design of product usability. Consequently, designers can enhance users' understanding of product usability by designing and incorporating 'clues' that appeal to particular areas of the intended users' experience (Chamorro-Koc and Popovic, 2008).

The preceding study established relationships between experience, context of use, and product usability from users and designers' knowledge representation about their 'use' of everyday type of products. The identified sources of experience were translated into design principles that aim to assist the design of product usability by informing designers about the aspects of human experience that trigger people's understanding of products (Chamorro-Koc et al, 2009). This knowledge advances an understanding of how people use products; nevertheless, further study is required to explore if same relationships influence designers' process for usability design.

## **Investigating causal relationships in the design of product usability**

This paper reports a work-in-progress that focuses on further understanding the role of experiential knowledge in the product design process. Through the observation of designers undertaking a usability design task, this study aims to identify the experiential aspects of designers' knowledge and its representation within the design process (Chamorro-Koc, 2008). It sits on the premise that design knowledge consists of explicit and tacit knowledge and that it is not only a reference to past experience but also an anticipation of the future (Friedman, 2001). It also considers studies in which various knowledge categories are identified such as descriptive, prescriptive or procedural (Vicenti, 1990). Therefore, this study is set out to investigate: how do designers design for usability? What types of designers' knowledge informs such process? And what kind of linkages between designers' individual experience, their knowledge of context of use and product usability take place during the design process? To address these questions an empirical study was undertaken involving sixteen product designers representing different age groups and levels of expertise. The study was conducted in two stages: (i) design stage, (ii) interpretation.

### ***Research Design***

This empirical study undertook a qualitative methodological approach and employed predefined design tasks that focus on the design of product usability. This research considers previous studies pointing out limitations of current approaches for uncovering design knowledge, in particular: (a) difficulties to observe designers in action and understand their creative process as not all design knowledge is externalised; and (b) difficulties to conduct an empirical study and observation with enough realism to simulate what designers do in real practice (Lawson, 2004).

To overcome these limitations, this study is set out as collaborative design in order to: (a) provide designers with a natural setting that prompt them verbalise their thoughts, (b) provide a means to fill

in gaps of information arising from the design brief that otherwise would be achieved via discussions with the client or experimentation with similar products. In this study, it is anticipated that facilitating designers to discuss the design task with a peer, will prompt different perspectives about the usability design issues. Observing the natural conversation between designers working on a design task will provide richer data about designers' experiential knowledge.

The study focuses on observing and investigating the early stages of the design process where usability issues are to be considered. It aims to identify the aspects of designers' experience and knowledge that are transferred into the design process, and the relevance of those aspects to the design of product usability. As it has been stated by other researchers, drawing is a useful source of insight into designers' knowledge; it provides a way to understand what they know (Lawson, 2004; Goel, 1995). The use of drawings to uncover experiential knowledge has been employed by Chamorro-Koc et al., (2008) in a study that focused on identifying people's concepts of product use. In this study, by employing drawings in a similar way, it is expected to identify aspects of designers' experiential knowledge influencing usability within the design process.

The pool of participants is comprised of product designers who are grouped in pairs for the collaborative design sessions. Designers are grouped according to their age group, gender and level of expertise, and they are invited to participate in a design session with two design tasks (Chamorro-Koc and Popovic, 2008). Experiment sessions are audio and video recorded and took place during 2008; data collected comprises: video-recorded observations, design sketches, and verbal protocols from design tasks and retrospective interviews. Table 1 summarises the research design.

Table 1: Research design summary

Objective	To investigate how designers design product usability, what informs their design process, the role their individual experience and episodic knowledge play within the design process
Expected outcomes	<ul style="list-style-type: none"> <li>• Identification of designers' experiential knowledge influencing the design of product usability</li> </ul>
Participants	<ul style="list-style-type: none"> <li>• Product designers representing differences in age, gender, and experience</li> </ul>
Design Brief	<ul style="list-style-type: none"> <li>• Two design tasks focussing on particular usability issues:</li> <li>• Design task 1: Design of Blood Pressure Monitor for elderly user</li> <li>• Design task 2: Design of Coffee Grinder for young professional multicultural couple</li> </ul>
Data collection methods	<ul style="list-style-type: none"> <li>• Observation</li> <li>• Design task simulation (design scenario and design brief)</li> <li>• Retrospective verbal protocol</li> <li>• Interview</li> </ul>
Experiment session	Sessions were organised in two parts: <ul style="list-style-type: none"> <li>• Part 1: Design task 1, retrospective report</li> <li>• Break</li> <li>• Part 2: Design task 2, retrospective report</li> <li>• Interview</li> </ul>
Setting	People and Systems Laboratory at Queensland University of Technology (Australia)

### ***The experiment session***

Two design tasks are involved in the experiment session. Each task dealing with usability issues particular to the user group identified in each design brief. It is expected that differences of design tasks would appeal differently to the designers, who might be knowledgeable about one topic but completely unrelated to the other one. This approach will help to compare design tasks and identify designers' experiential knowledge underlying their design process.

Data collection is organised into *two stages*: (i) design and (ii) interpretation. The design stage focuses on a design task which is presented through a design brief and a scenario. Figure 1 illustrates the design scenario and design brief presented to the designers.

**Design Task 2: Coffee grinder**

Mei and Josh are a middle age professional couple who are enjoying their life together. They have spent time in developing common interests, like collecting Alfred Hitchcock movies and experimenting with B/W photography. Now they are into coffee and the diversity of flavors, aromas and types of coffee (espresso, cappuccino, latte, etc). They usually buy the coffee already packed, however they have found out that they can make their own combinations. They have decided to buy a coffee grinder so that they can create their very own combination of coffee.

**Design Brief**

The design task is to design a domestic coffee grinder that allows at least 3 or 4 types of grinds according to the various types of coffee. The grinder capacity should allow for the equivalent of 2 cups of coffee, and it should allow for ease of use when measuring the amount of coffee required for 1 or 2 cups. Usability aspects of the design must be the focus of the design.

Figure 1: Design scenario and design brief

In the design stage, designers are asked to work collaboratively and produce initial concept designs. The interpretation stage focuses on a retrospective verbal report in which designers are asked to describe the design concepts generated in the design stage.



Figure 2: Design stage



Figure 3: Interpretation stage

Figure 2 illustrates a segment when both designers are producing and drawing their own ideas. It must be noted that this was prompted by initial discussion of the design brief and utilisation of their knowledge about the product based on individual experience. Initial ideas were triggered after consideration of the various aspects outlined in the design brief. Concepts were then developed upon an iterative reflective process of design issues that were known to the designers or that were previously experienced. Outcomes from this stage consisted on: drawings, annotations, and observations of the collaborative design process in which designers' individual experience were verbalised. This data is later employed to gain insights about the ways designers incorporate their individual experience, knowledge of product and context of use into their design concept.

Figure 3 shows a segment of the interpretation stage session in which designers are describing their concepts, ideas and the design process undertaken. This session focuses on understanding the

designers' design outcomes through their own interpretation. Retrospective verbal reports are employed to collect a description from the designers' own perspectives about the design task represented in the sequence of sketches (Hannu and Pallab, 2000). After the design task 1 and 2, questions presented to the participants were: (i) please describe your design as it is in the sketches, tell us about the design process, and (ii) how did you address product usability in this design? At the end of the session, an open ended interview is conducted to ask designers about any other issue arising from the initial observation of sketches, and provide the researcher an opportunity to ask about any gaps or doubts arising from the retrospective report. The final interview questions are: (iii) please compare design tasks 1 and 2: Which design do you think addresses usability issues better? Was one of the tasks more appealing to you? Why?

## Analysis of initial results

Drawings, annotations, and verbal reports were analysed and interpreted; this process aimed at identifying references made to usability and experience issues in visuals and verbal reports (Chamorro-Koc, Popovic and Emmison, 2008). The interpretation and analysis of visuals and verbal reports is assisted by ATLAS.ti, specialised software to assist qualitative analysis of data. From the data, textual and visual references to designers' knowledge, design process, usability issues, and type of solutions, were identified by the researcher and established as a system of coding categories. Table 2 shows the coding system.

Table 2: Coding scheme

Category	Code	Description
Experience (personal)	<b>IE</b>	Individual experience (of doing-using) – tacit knowledge
	<b>EE</b>	Episodic experience (memory) – situated experience/knowledge
Use (ways of use)	<b>Tu</b>	Typical use (function/ intended use) – current mental model
	<b>Au</b>	Anticipation – idea of future use (assumption)
Solution (artefact)	<b>Ps</b>	Prototypical solution or prescribed/general knowledge (adaptation or typification of knowledge)
	<b>Cs</b>	Creative solution – new design
	<b>PBC</b>	Principle base concept (tacit knowledge: knowing how - procedural)
	<b>DBC</b>	Descriptive base concept (explicit knowledge?)
Context	<b>Ac</b>	Activity
	<b>St</b>	Situation (physical, social, etc)
Usability	<b>Eu</b>	Ease of use (how easy or difficult it is to use?) – future use
	<b>Iu</b>	Intended use (what – how –where?) – new design
Process	<b>Ds</b>	Discovery (solo ideation – new ideas)
	<b>Rf</b>	Reflective (while discussing, outcome from participatory context)
	<b>AnU</b>	Analysis of the user (or 'use')
	<b>AnP</b>	Analysis of the product

The emerging coding system reveals different types of experience. In strict relation to the focus of this research, the coding system aims to identify references to the designers' individual experience with similar products (tacit knowledge); reference to a particular experience situated in particular context (individual or episodic experience), procedural knowledge, and anticipation of future experiences. Codes also aim to identify the usability aspects considered by designers, thus, aspects of the process are identified as reflective, discovery, creative; and usability issues have been referred to aspects of 'use', for example: intended use, ease of use.



The coding system was applied to the appropriate segments of text or drawing produced by the designers. For example, figure 4 shows an image of a coffee grinder designed by a pair of novice female designers (20 years old) and who have some work experience at coffee shops. In this section of the drawing, the code 'Principle Base Concept' (PBC) has been applied as it refers to the product design described by the rationale behind its functions. In this instance the drawing suggests that the designer knows how this type of product works and therefore, he has tacit knowledge of the assembly and function of the product, and thus, it indicates that tacit knowledge informs their usability design.

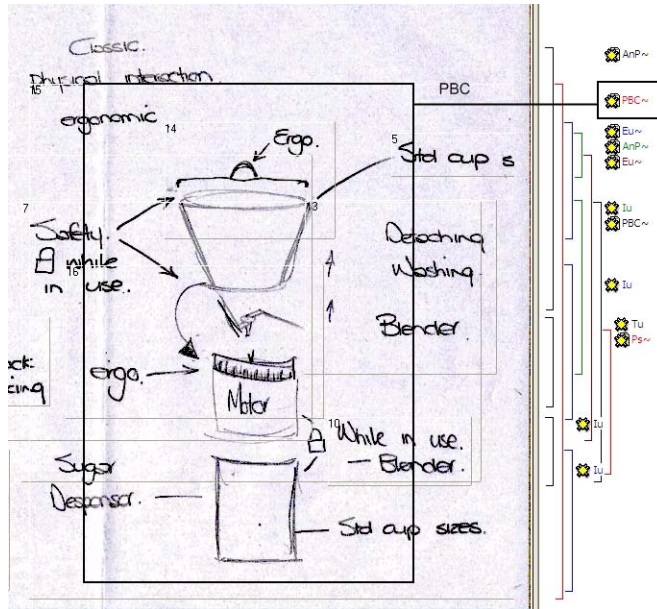


Figure 4: Exemplar of an application of the coding system

Each drawing and transcription were analysed by applying the relevant codes. Three independent coders did the coding in order to achieve consistency and eliminate potential bias. In addition, memos and notes were used to note discrepancies, uncertainties, ambiguities or other characteristics which were to be discussed after the coding was completed. This approach helped to validate the coding.

## Initial interpretation of results

Observation of code frequency and how codes relate to one another at particular segments of drawings and transcriptions from verbal protocols was employed to respond a set of questions outlined for the final analysis. This set of questions provided the basis for the initial interpretation:

- How do designers inform usability design? (sources of design knowledge: prototypical, assumption, experience)
- What types of 'designers' knowledge' inform usability design process? (tacit, explicit, adapted?)
- How do they design for usability?
- How do designers know their design is useful for intended users?

Responding to these questions helped the interpretation of how the designers have applied various levels of knowledge, experience and understanding of context of use to inform usability design. Table 3 summarises findings emerging from the initial interpretation.



Table 3: Summary of initial findings

Analysis question	Related codes
How do designers inform usability design?	DBC, PBC, Ps, Au, Tu, Cs
What types of designers' knowledge inform usability design process?	IE, EE
How do they design for usability?	Ds, Rf, AnU, AnP
How do designers know their design is useful for intended users?	Eu, Iu, Ac, St

For example, it was found that expert designers demonstrate a variety of design knowledge to inform their usability design. Such knowledge is evident in their representation and explanation of their concept designs, where solutions go from description base concepts (DBC), to detailed explanation of principle base concepts (PBC). Their knowledge comes from individual experience (IE) and episodic experience (EE); thus, it can be inferred that their usability design process is informed by the designers' tacit knowledge. In designing for usability issues, expert designers refer predominantly to the user's capabilities emphasising aspects of ease of use (Eu), intended use (Iu), references to the activity (Ac) and situation of use (St). The design process manifested by expert designers demonstrates a thorough assessment of solutions based on user (AnU) and context, and this process leads to 'solo' discovery moments (Ds), as well as iterative reflection (Rf). Finally, designers assess usefulness of their concept designs based on consideration of ease of use (Eu) and intended use issues (Iu), for which they refer to their individual experience and assumptions of future use.

In order to discuss indicative results, an initial comparison of data corresponding to a different category of: age, gender and expertise is presented. Comparison consisted of the following groups:

- Group Age: 20 year-old designers compared against 40 year-old designers
- Group Expertise: Novice/Expert designer compared against Expert/Expert
- Group Gender: Male/Female designer team compared against Female/Female team

#### ***Group Age: (20s + 20s) compared against (40s + 40s)***

The group consisting of two expert designers in the 40 year-old age category applied a consistent design methodology which drew on a broad range of experience, knowledge sources and understanding of context of use to inform their usability design. This was evident in the discussion taking place during the design stage. The expert group made significant references to their individual experience throughout their design activities, and provided the highest diversity of usability design knowledge and application. This knowledge was evident in their design solutions, which they explained around the topics of ease of use, intended use, activity and context. Comparatively, the group consisting of two 20 year-old designers applied an inconsistent and moderate understanding of context of use, experience and knowledge to inform their usability design.

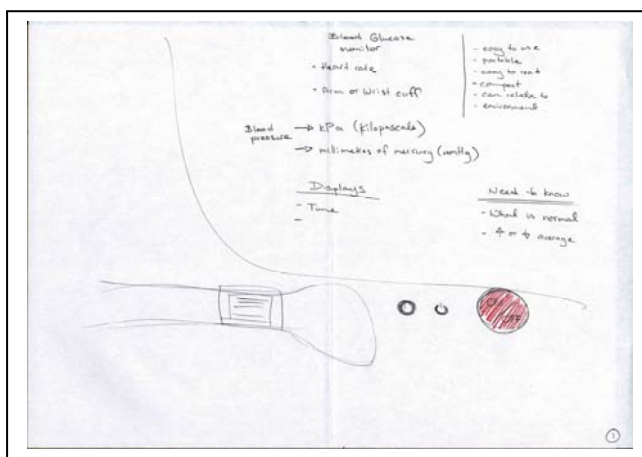


Figure 5: 20s year-old designers' concept

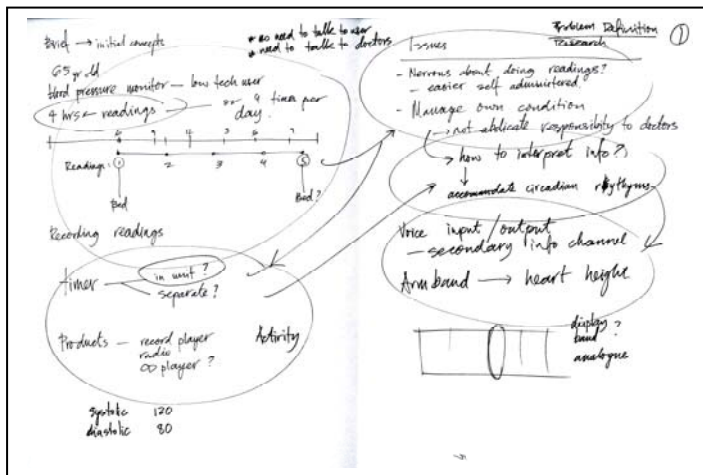


Figure 6: 40s year-old designers' concept

For example, figures 5 and 6 illustrate design outcomes from the 20 and the 40 year-old designers. In figure 6 it can be noted that usability aspects considered by the 20 year-old designers are mostly around the physical aspects of use of the product. They refer to the display, a portable device, the colour of the on/off button, and mention the 'ease of use' without identifying what makes this solution easy to read or to use. Differently, figure 6 shows that the 40 year-old designers considered various 'use' aspects of the design problem. They considered the type of information that must be available for the user, and the format in which this should be presented for ease of reading; types of input and output, the issue of 'how to use' the device; and the context in which the device would be used. Figure 7 shows only one part of the concept design, many more details of this concept development are presented in other drawings not shown here.

### **Group Expertise: (Novice + Expert) compared against (Expert + Expert)**

As described previously, the expert designers made significant references to their individual experience to inform their usability design. Comparatively, the group consisting of one expert (more than ten years of experience) and one novice designer (recent graduate) demonstrated an inconsistent application of different sources of knowledge. This is evident in the drawings and their retrospective interviews. For example, the collaborative design prompted a rich discussion about their individual knowledge and episodic experiences relevant to the design problem. Although such discussion resulted in the consideration of future contexts of use, it produced a limited concept development, where usability issues were considered second to the mechanical and functional aspects of the design. Nevertheless, during the interpretation stage, both novice and expert demonstrated knowledge and understanding of the context of use and usability aspects, drawing from diverse sources of experience; which were not referred to during the design stage.

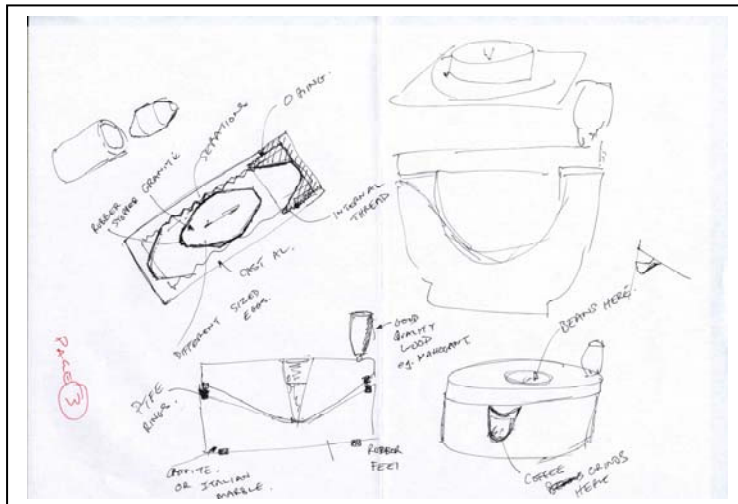


Figure 7: Novice/Expert designer concept

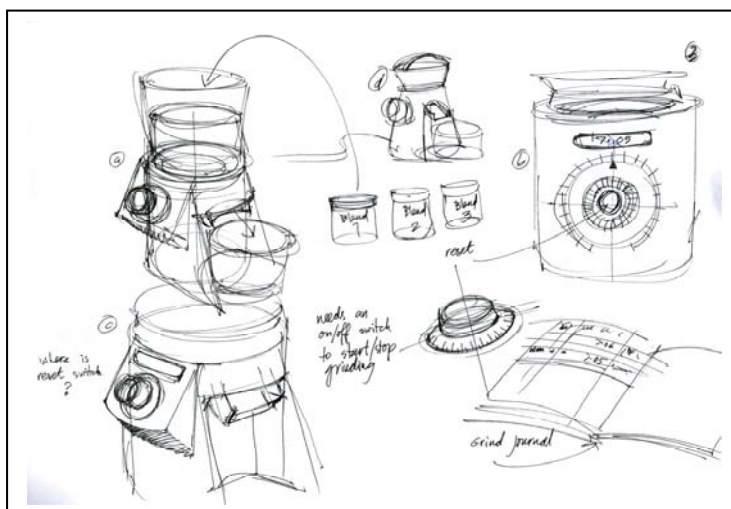


Figure 8: Expert/Expert designer concept

Figure 7 shows the novice/expert designers' concept design; it elaborates on the details about features, functions and mechanism of the product. Differently, figure 8 presents the expert designers' concept design, demonstrating not only understanding of the principles behind the functions and use of this type of product, but also it presents a 'story' behind the product use. This story refers to a particular function of the product, a type of 'selection' or 'setting', which can be recorded for future uses.

### **Group Gender: (Male + Female) compared against (Female + Female)**

The group consisting of one male and one female designer refer to a diverse range of experience and understanding of context of use to inform their usability design. This was mainly observed from their discussion during the design stage. They referred to various past and episodic experiences relevant to the use of the product showing different points of view about the current and future use of the product. This discussion produced different ideas that they elaborated on, and transferred into concept designs. Comparatively, the group consisting of two female designers demonstrated similar points of views and experiences about the use of the product. Their discussion produced limited design concepts and low variety of ideas. Usability aspects relevant to ease of use and context of use were mentioned but not developed. Figure 9 shows the female/male designers' concept; the drawing shows a series of steps describing the different issues considered as part of the design process and three possible design directions. These solutions assume a future context of use. Figure 10 illustrates the female/female

designers' concept, which emphasises mainly on the parts and main function of the product. Their design concept is based on a context of use they know.

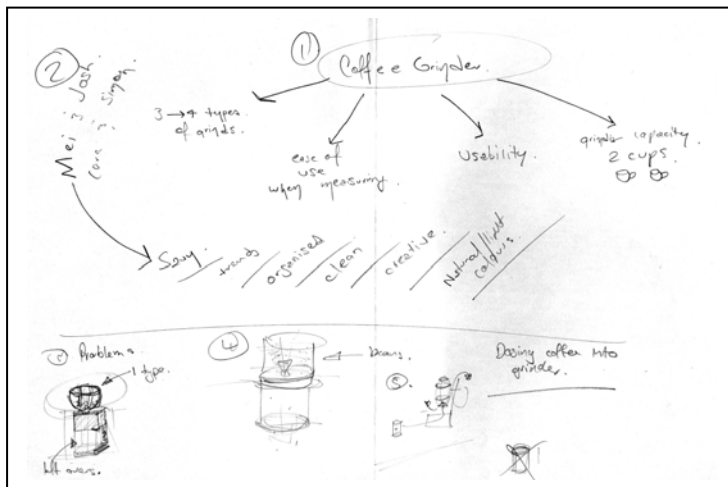


Figure 9: Male/female designers' concept

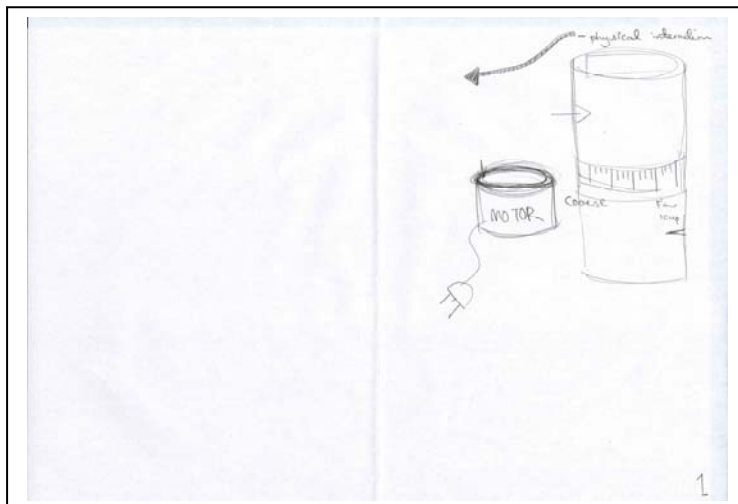


Figure 10: Female/female designers' concept

## Conclusions

Initial results show that designers' knowledge comes from their experience of using products or from episodic experience. It also demonstrates that designers transfer their experiential knowledge into solutions where tacit knowledge is represented thorough the procedure of a product's use, or into basic descriptions of features. Results also show that designers prefer to develop design concepts based on anticipatory knowledge (assumptions or predictions) rather than generalizing (or adapting) known solutions.

At this stage of the analysis, this study shows that designers' experiential knowledge influences the way they reinterpret the design task, and drives the usability design process. Designers' individual experience mandates the implementation of usability issues as part of the early stage of design process; where novice designers are less constrained than expert designers and design from assumptions of future experiences. These outcomes demonstrate the influence of various aspects of designers' tacit knowledge and experience in the design of product usability. Results also indicate that

the collaborative design approach was critical in order to identify the role of designers' individual experience and the types of knowledge they use to inform usability design during the design process.

As this paper reports a work in progress, the final part of the analysis remains to be concluded. It is expected that comparisons among groups will help establish specific relationships between individual experience, knowledge of context of use, and the design of product usability. Identifying those relationships will complement the knowledge gained from Chamorro-Koc (2008) previous research, where similar relationships were found from the users' point of view. Knowing about users and designers' different views about product usability, and the sources of experience prompting that knowledge will contribute to our understanding of user-product interactions, and therefore, it will contribute to develop theory to better support usability within design process.

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